

the charging pressure was connected to these points and observations taken, when the exciting current for the field magnets of the dynamo and the charging current to the pipe were practically the same as in a previous set of experiments, for which the charging volts were known. Both sets of experiments are shown in the table. The disturbance of the worms was again very distinct, and they appeared, on reaching the surface, to set their bodies parallel to the pipe, or along an equipotential line.

The experiments, as a whole, show conclusively that, under very different conditions of weather and amount of moisture in the soil, it is possible to produce a fall of potential amounting to 25 per cent. of the whole pressure in the supply between points on the surface of the ground 4 ft. apart, a distance which most horses stand over, and, further, that, although the connexion of such points by a conducting body naturally reduces this potential difference, yet, when this conductor has about the resistance of a horse (say 400 ohms), sufficient current will pass to give a severe shock.

It is hoped that, when opportunity serves, these experiments may be extended to the case of pipes buried to greater depths, and to observe whether any difference is produced by the use of a steady, in place of an alternating pressure.

VI. "On the Viscosity of Water as determined by Mr. J. B. Hannay by means of his Microrheometer." By ROBERT E. BARNETT, A.R.C.S. Communicated by Professor T. E. THORPE, F.R.S. Received May 6, 1894.

In a paper entitled "On the Microrheometer," published in the 'Philosophical Transactions' for 1879, Vol. 170, p. 275, Mr. J. B. Hannay describes an apparatus with which he made measurements of the rate of flow of water, and of some aqueous saline solutions through a capillary tube, and he deduces from the observations certain relations between the chemical nature of the salt dissolved, and its effect on the rate of flow of water.

Inasmuch as Mr. Hannay furnishes us with details of the dimensions of his apparatus, I have, at Professor Thorpe's suggestion, transformed his relative numbers into absolute measure of viscosity in order to compare his results with those of other workers. The data given are as follows:—

Diameter of capillary tube	=	0.0938 mm.
Length	„	= 21 mm.
Capacity of glass bulb	=	4.0530 c.c.

The time of flow was measured by a stop-watch, and each number recorded was the mean of ten observations.

s 2

In calculating the value of the viscosity of water from Mr. Hannay's figures, the well-known formula

$$\eta = \frac{\pi r^4 p t}{8 V l} - \frac{V \rho}{8 \pi l t}$$

was employed, in which—

η = Viscosity in dynes per sq. cm. in C.G.S measure.

r = Radius of the capillary in cm.

l = Its length in cm.

V = Volume of liquid transpired in c.c.

ρ = Its density at the temperature of observation.

p = Pressure in dynes per sq. cm. ($g = 981$).

t = Time of flow in seconds.

On applying this formula to the experimental results given for water, the figures embodied in the subjoined table (I) were obtained. In Columns 1 and 2 are the temperatures of observation and the corresponding times of flow as recorded by Mr. Hannay. Columns 3

Table I.

1.	2.	3.	4.	5.
T°.	t .	$\frac{\pi r^4 p}{8 V l} \cdot t$.	$\frac{V}{8 \pi l} \cdot \frac{\rho}{t}$.	η .
0	235.0	0.000514	0.000327	0.000187
1	220.8	0.000483	0.000348	0.000135
2	211.7	0.000463	0.000363	0.000100
3	205.0	0.000449	0.000375	0.000074
4	198.5	0.000434	0.000387	0.000047
5	192.5	0.000421	0.000399	0.000022
6	187.1	0.000409	0.000410	-0.000001
7	181.0	0.000396	0.000424	-0.000028
10	167.2	0.000366	0.000459	-0.000093
15	146.0	0.000320	0.000526	-0.000206
20	131.3	0.000287	0.000584	-0.000297
25	115.5	0.000253	0.000663	-0.000410
30	106.0	0.000232	0.000721	-0.000489
35	96.8	0.000212	0.000789	-0.000577
40	88.7	0.000194	0.000859	-0.000665
45	81.8	0.000179	0.000930	-0.000751
50	75.5	0.000165	0.001005	-0.000840
60	65.0	0.000142	0.001162	-0.001020
70	57.5	0.000126	0.001306	-0.001180
80	49.8	0.000109	0.001499	-0.001390
85	47.1	0.000103	0.001579	-0.001476
90	45.5	0.000100	0.001630	-0.001530
95	44.3	0.000097	0.001688	-0.001571
100	43.8	0.000096	0.001681	-0.001585

and 4 contain the calculated values for the first and second parts of the formula respectively, and in Column 5 are the values for the viscosity obtained by subtracting the figures in Column 4 from those corresponding to them in Column 3.

On comparing these results with the values given by Poiseuille, Slotte, Sprung, and Thorpe and Rodger as tabulated below (II), it will be seen that Mr. Hannay's observations yield discordant, and, indeed, utterly absurd, values for the viscosity of water. At 0°, for example, the viscosity would appear to be below that of any known liquid, and at 6° it becomes *nil*.

Table II.—Water.

Viscosity Coefficients in Dynes per sq. cm. between 0° and 100°.

Temperature.	Poiseuille.	Sprung.	Slotte.	Thorpe and Rodger.
0	0·01776	0·01778	0·01808	0·01778
10	0·01309	0·01301	0·01314	0·013025
20	0·01008	0·01003	0·01008	0·010015
30	0·00803	0·00802	0·00803	0·007975
40	0·00653	0·00657	0·00657	0·006535
50	..	0·00553	0·00553	0·005475
60	..	..	0·00472	0·00468
70	..	..	0·00408	0·00406
80	..	..	0·00358	0·00356
90	..	..	0·00318	0·003155
100	..	..	0·00285	0·00283

As a matter of fact, it is physically impossible to pass a volume of water such as Mr. Hannay employs under a pressure of 1 m. of water through a capillary of the dimensions given in the time recorded. At 20°, for instance, the time of flow required under these conditions would be about 4600 seconds instead of 131·3 seconds as stated.

I have carefully examined Mr. Hannay's data with the object of discovering any slip or misprint which might satisfactorily account for the discrepancy. Thus, I have tried the effect of substituting "centimetre" for "millimetre," and "radius" for "diameter" in the dimensions given, but no alteration of the kind could be made to yield values for η agreeing with those of other observers.

In the light of these results, it would seem to be premature to discuss Mr. Hannay's observations on saline solutions, or to criticise the generalisations he deduces from them.